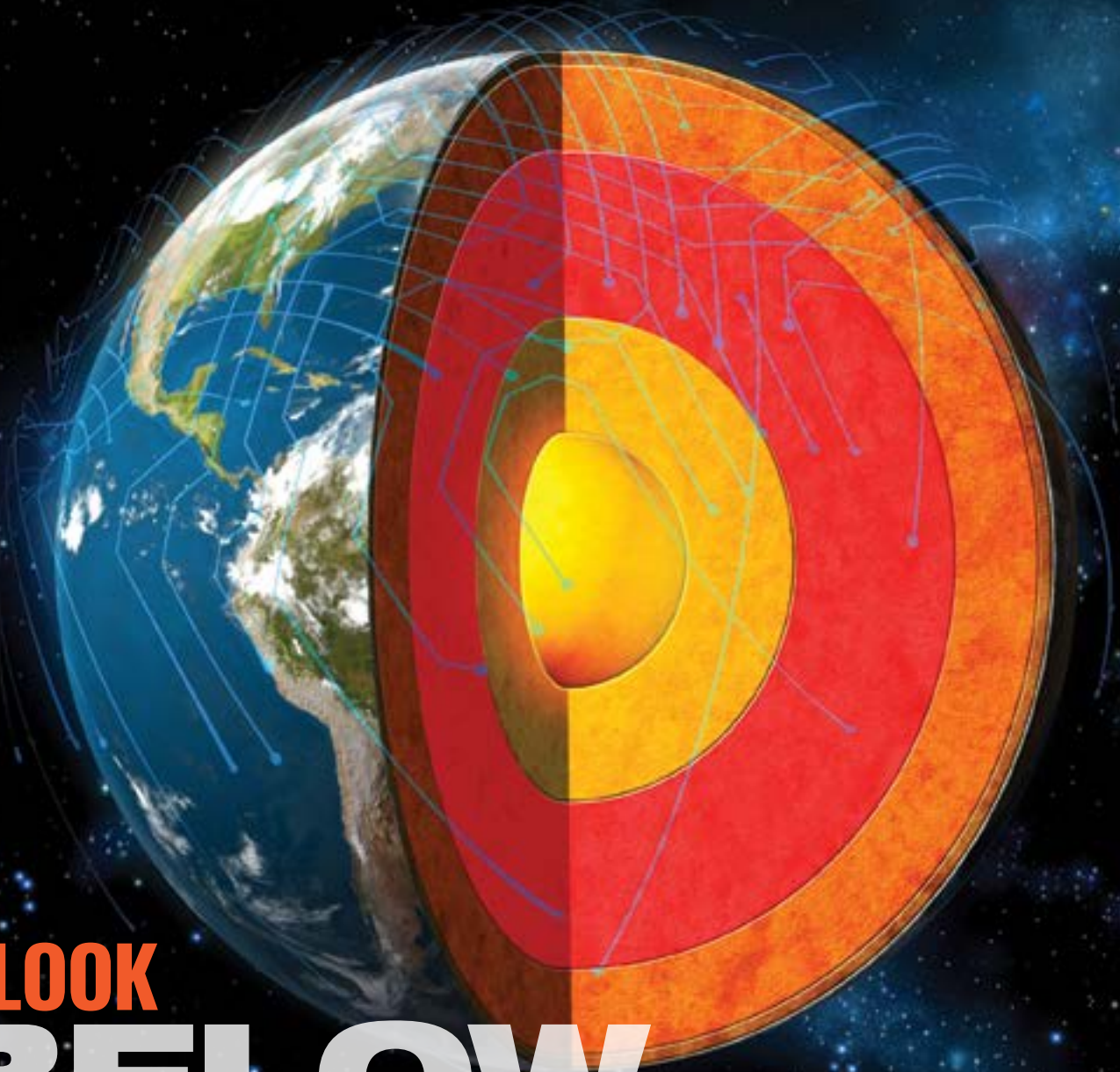


MINES MAGAZINE

For Colorado School of Mines Alumni and Friends • Fall 2022



A LOOK BELOW THE SURFACE

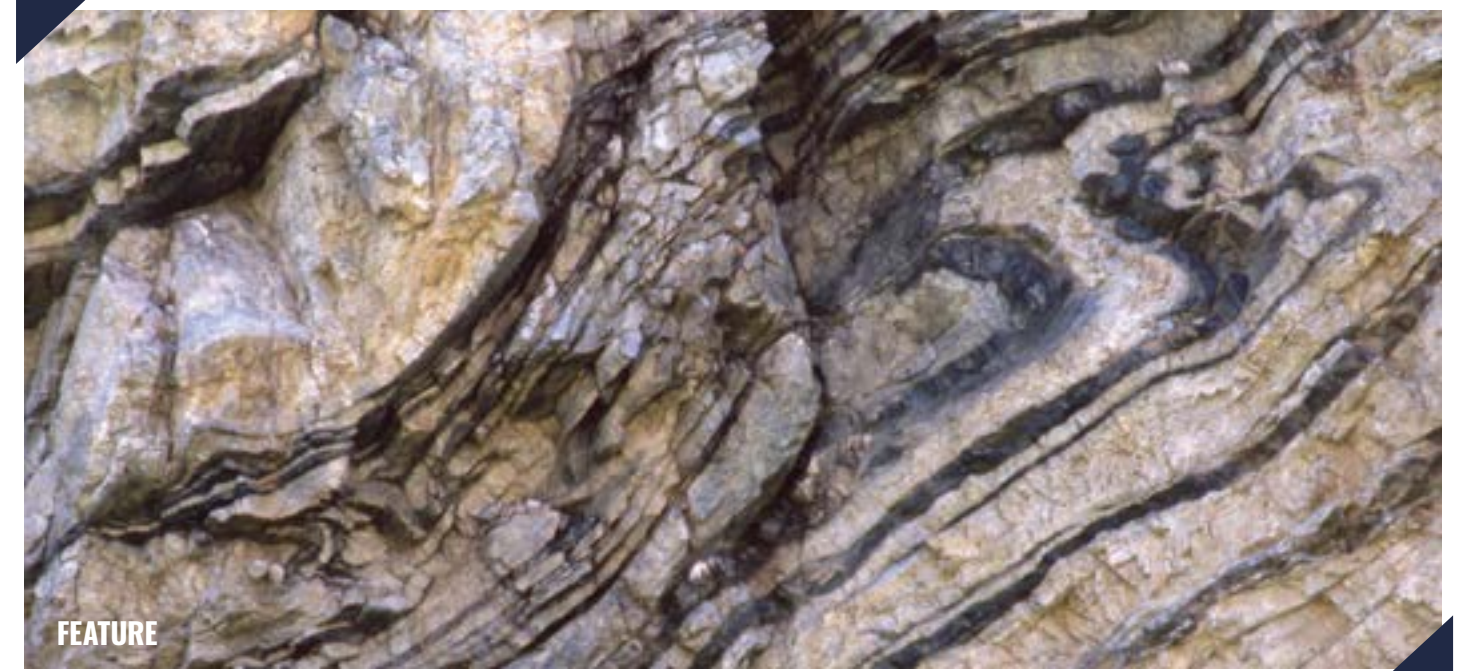
The field of geophysics has grown significantly in the past century and continues to enable future innovation in energy, infrastructure, space exploration and more.

PLUS:

Mines researchers are finding creative solutions to major challenges in infrastructure and manufacturing.

Space exploration requires navigating intellectual property laws—and a Mines alum is prepared to help.

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A LOOK BELOW THE SURFACE

Geophysics—and our understanding of the Earth’s subsurface—continues to gain importance in meeting energy and mineral demands, monitoring critical infrastructure, exploring other terrains in our solar system and more. **18**

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SKILL SET



Mines alumni run an urban farm focused on sustainability and community engagement. **30**

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Have you heard of Little Free Libraries? How about a little free museum? The Mines Museum of Earth Science opened a mini museum along Clear Creek Trail behind the Golden History Museum for anyone to stop by and grab a free rock, mineral or fossil specimen.

→ Follow Mines on social media for more great shots of the Mines community and Golden and to keep up with everything happening with your fellow Orediggers.



On the cover: Geophysicists are leading efforts for understanding the Earth’s subsurface for a wide array of applications, including finding valuable resources, maintaining critical infrastructure, enabling exploration beyond our planet and more.

Giving back with your

TIME,
TALENT &
TREASURE

as an OreGiver

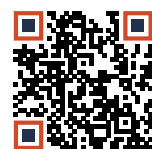
Bill Zisch '79, Dave Zanetell '87 and Steve Chesebro' '64 have a few things in common. They attended Mines on athletic scholarships. They played Oredigger football. They have children who are Mines students or alumni. And they are OreGivers—people who donate their time, talent and treasure to Mines and through Mines.

Zisch, Mines Alumni Board President, volunteers to create meaningful opportunities for Mines alumni. "We're helping students in the student-to-alumni transition and working with interest groups that connect the school and alumni with industry. And we're helping alumni connect with Orediggers wherever they are."

Zanetell recently talked to graduating football players about transitioning their on-field

leadership to the workforce—including their competitive spirit and "we before me" culture. "What starts as a \$5 donation early in your career will grow over your life's journey. Alumni paying the opportunity we received forward by being engaged and giving has made Mines athletics what it is today."

Chesebro' helped found the Houston Endowed Scholarship Golf Tournament, which has given out \$750,000 in academic and athletic scholarships since 2000. "Without the Mines education, I would not have achieved my potential. A good way to pay that forward is to provide support to enhance all aspects of the school, including athletics."



Learn more



Steve Chesebro' '64



Bill Zisch '79



Dave Zanetell '87

How can YOU be an OreGiver?

- **Volunteer** with your local M Club
- **Cheer** on Oredigger football (or volleyball, or swimming ...) from the stands
- **Donate** to a Silver and Blue athletics scholarship fund
- **Share** your expertise in an alumni interest group
- **Mentor** a current student
- **Connect** students with internship and employment opportunities

HOW MINES STACKS UP

The university comes out on top in several national rankings in 2022

No. 2 highest return-on-investment for low-income students, Georgetown University

No. 3 in a list of the top 10 engineering colleges, Money Magazine

No. 17 for Best Online Master's in Engineering Management, U.S. News & World Report

Research 1 (R1) classification by the Carnegie Classification of Institutions of Higher Education, the highest and most prestigious designation granted to U.S. research universities

2023 U.S. NEWS & WORLD REPORT RANKINGS

Mines maintained its place as the top national university in the state of Colorado and ranked high among national universities in the U.S.

No. 20 in most innovative schools

No. 38 in top public schools

No. 41 in best undergraduate teaching

No. 45 in best undergraduate engineering programs - overall

No. 56 in best colleges for veterans

No. 89 in national universities

➔ For more on how Mines stacks up against other universities, go to mines.edu/about/rankings.



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IN THE HOME STRETCH

An update on what we've accomplished and what's still ahead leading up to Mines' sesquicentennial

We're less than two years away from a major Mines' milestone—our 150th anniversary in 2024. Here in *Mines Magazine*, I've shared our MINES@150 plan and progress toward our goals. I've also discussed these with you at events and alumni gatherings, and many of you have jumped in to help us move toward becoming that unique top-of-mind and first-choice university we aspire to be.

Now, in the home stretch, we're starting to see the impact of our hard work. That's evident in our incoming classes of students, our new faculty and staff, the companies recruiting our graduates, the engagement of alumni, the investments from our donors, and the growing sense of pride in what's being accomplished.

FOR EXAMPLE, WE'RE:

- Expanding professional development opportunities for students to prepare them for successful careers and life beyond Mines.
- Creating an entrepreneurship and innovation ecosystem for our students, faculty and alumni to create new products, processes and companies.

- Offering new undergraduate degree programs in today's top engineering and business fields.
- Giving students opportunities to enter into honors and scholars programs focused on leadership development.
- Increasing accessibility to a Mines education with 20+ new online programs.
- Connecting students and alumni through special interest groups and mentoring programs.
- Building the Labriola Innovation Complex and Beck Venture Center (expected to open in Summer 2023).
- Developing our early childhood education center (groundbreaking anticipated in late 2022).
- Planning a second classroom building/parking garage combo (construction start anticipated in early 2023).
- Building the Minerals and Energy Research Facility, in partnership with the U.S. Geological Survey (construction start expected in mid-2023).
- Expanding student housing for years two to four and graduate students (planning underway).

This is just a small snapshot, but there's a lot going on at Mines as we head towards our sesquicentennial. It's been exciting to see alumni involvement grow, too, and there's still time and opportunities for you, no matter where you are in the world.

Volunteer to mentor students; share your professional experience and expertise as an in-person or virtual guest speaker in a class or one of our professional development workshops; join one of the alumni interest groups; and more.

Open doors for internships/jobs for students, faculty collaborations and research projects and new Mines-industry partnerships.

Invest in students, academic program excellence and our MINES@150 initiatives.

I'm looking forward to the celebration we'll have in 2024. Thank you for all you do to support and share your pride in Mines.

Go Orediggers!

Paul C. Johnson
President and Professor

➔ Follow our progress at mines.edu/mines-at-150.

GEOLOGIST IN CHARGE

Mines alum becomes State Geologist, Colorado Geological Survey director

BY EMILIE RUSCH

Matthew Morgan is the new Colorado State Geologist and director of the Colorado Geological Survey (CGS).

A Colorado School of Mines alum, Morgan took the reins of the state government agency in September. He previously served as CGS' deputy director and senior research geologist.

The Colorado Geological Survey has been part of Mines since 2013 when the state of Colorado transferred the agency to the university.

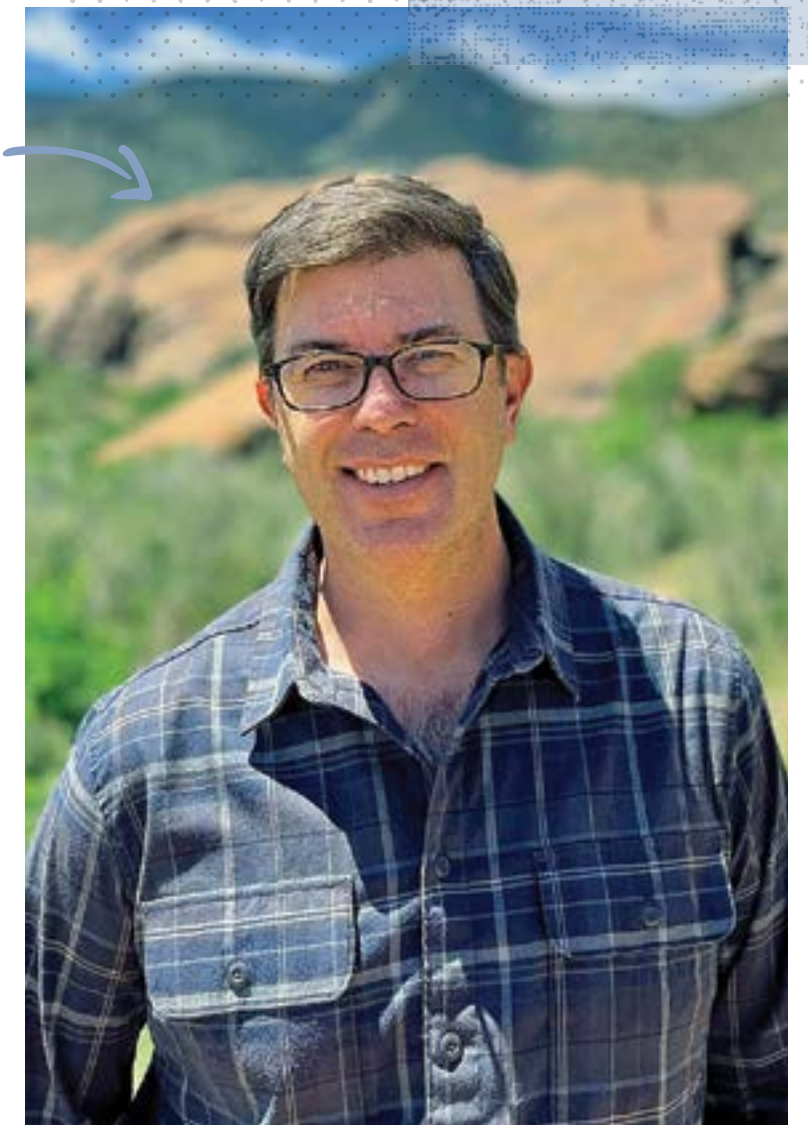
Morgan has worked for CGS since 1996 in a variety of roles. He holds a master's degree in geology from Mines and a bachelor's degree in geology from the New Mexico Institute of Technology.

An active promoter of geosciences and STEM activities to Colorado schools and organizations, Morgan has authored or contributed to more than 100 journals, reports, maps and proceedings volumes on topics ranging from geomorphology, minerals, landslides, earthquakes and meteorites.

Morgan recently received the GSA/AASG John C. Frye Memorial Award for his work on the CGS publication, *The West Salt Creek Landslide: A Catastrophic Rockslide and Rock/Debris Avalanche in Mesa County, Colorado*. He continues to work on many scientific projects and manages the Geologic Mapping Program for Colorado.

Among Morgan's goals as director is to promote CGS, expand programs and diversify the CGS project portfolio—including groundwater resources and the areas of carbon capture and sequestration, and geothermal energy—and continue to more closely integrate into Mines.

"The Colorado Geological Survey is now part of a world-class science and engineering institution. We have access to highly respected research partners, students and



laboratories. We are in the early stages of integration with the Mines community. Opportunities abound through collaborative research, hiring and mentoring high-caliber students, curriculum development and interdepartmental information exchanges," Morgan said. "As State Geologist, I will be involved on campus and promote collaboration between Mines and CGS at every opportunity."

Founded by the state Legislature in 1907, the Colorado Geological Survey's mission is building vibrant economies and sustainable communities, free from geologic hazards, for people to live, work and play through good science, collaboration and sound management of mineral, energy and water resources.

One of its primary efforts is to help people live safely with the multitude of geological hazards that Colorado's spectacular geology creates when people move into nature. CGS is required by statute to review geologic reports done for new developments in unincorporated parts of counties and for all new school construction or critical facilities.



A QUICK LOOK AT THE CLASS OF 2026

- 1,665** new first-year and transfer students
- 31.4** percent women
- 26.6** percent underrepresented domestic ethnic or racial groups
- 16.6** percent first-generation college students
- 2.2** percent international students
- 49** states and U.S. territories represented
- 18** countries represented
- Top 3 U.S. states outside Colorado: **Texas, California, Washington**
- Top 3 countries outside U.S.: **Saudi Arabia, South Korea, Mexico**



NEW GEOSCIENCE MAKERSPACE ON CAMPUS

— A new geoscience makerspace opened on campus, giving undergraduate and graduate students a place where they can experiment with novel forms of instrumentation and try out their designs related to Earth observation.

Located in the Green Center, students can utilize the space to build and test equipment, which can then be used for research out in the field. Projects being worked on in this space include an effort to build low-cost geoscience sensors that can be attached to drones and robotic vehicles, expanding their capabilities in Earth observation.

“We want to encourage students to embrace design challenges and use their creativity to create instrumentation that better suits their research and projects,” said Jeffrey Shragge, associate professor of geophysics. “It’s sometimes more productive to customize equipment instead of buying new, in terms of both cost effectiveness and really creating what you need. By getting hands-on experience with instrumentation, students also become more familiar with how they operate, and can troubleshoot should they need to while acquiring data.”

CONNECTIONS

► Have you run into a fellow Oredigger in an unusual place? Gone on a trip with classmates? Visited campus to share your expertise? We want to know all about it! Send us your connections at minesmagazine.com/connection. ▲

NEW LEADER FOR MINES’ STUDENT LIFE OFFICE

— Mines selected Braelin Pantel as its next vice president of student life. A 20-year veteran of higher education in Colorado, Pantel previously served as associate vice president for student engagement and wellness and dean of students at Metropolitan State University of Denver.

As vice president of student life, Pantel serves as Mines’ chief student affairs officer and oversees all of the institution’s student programming and services, including advising, student activities, athletics, residence life and dining, health services, student counseling, accessibility services, fraternity and sororities, student professional development, career services and more. As a member of the president’s executive cabinet, Pantel will play a key role in advancing Mines’ strategic priorities for student recruitment, success and professional development.

“Mines students are coming to campus with intentionality and passion for their academic pursuits and that’s really powerful when it comes to student engagement, student support and student life,” Pantel said. “I’m committed to creating a healthy and safe campus environment where Mines’ diverse students thrive. I’ve done a good deal of work related to student access to mental health and have created structures within a university community that prioritize student wellness. I’m excited to continue to do this work within the Mines context and partner with colleagues across the institution in doing so.”



PURSuing A MASTER’S DEGREE IN MECHANICAL ENGINEERING—ONLINE

— An online master’s degree in mechanical engineering launching next year will offer the same depth and rigor of the on-campus experience with the convenience of online learning.

The non-thesis master’s program was designed with flexibility in mind, both for working engineers looking to advance their careers and for graduate students looking to continue their education without having to relocate for a residential program. The fully online classes will be eight weeks long, with high-quality prerecorded lectures specifically designed for online learning, regularly scheduled opportunities for live interaction with faculty and the flexibility to complete assignments when it best fits a student’s schedule.

Students can also customize their path based on interests and existing expertise. A total of 10 courses are required for the non-thesis MSME degree, with electives available in additive manufacturing, combustion, continuum mechanics, finite element analysis (FEA), fluid mechanics, fracture mechanics, heat transfer and more.

“This is the same non-thesis MS we offer on campus—we’re not pulling any punches here,” said Tony Petrella, program director and associate professor of mechanical engineering at Mines. “We’re simply leveraging online instruction to provide broader access to the richness of our residential graduate program—without the geographic and scheduling constraints. The requirements for the degree, the learning goals and the value will all be the same.”

► Alumni and friends hosted 23 separate welcome parties in cities across the country in July and August to welcome new students to the Mines community and celebrate the start of the new academic year. ▲



Photo by Jordan Menard

DILLON POWELL'S 2021-22 ACCOMPLISHMENTS

NCAA Division II 10K National Championship

High Point Athlete of the Meet at the NCAA Division II Outdoor Track & Field Championships

3 First-Team All-America awards from the U.S. Track & Field and Cross Country Coaches Association

USTFCCCA South Central Athlete of the Year

4 All-Region awards from the U.S. Track & Field and Cross Country Coaches Association

RMAC Runner of the Year

RMAC Indoor Track Athlete of the Year

RMAC 10K Champion

2 First-Team All-RMAC Awards

2 National Athlete of the Week awards from the U.S. Track & Field and Cross Country Coaches Association

5 RMAC Athlete of the Week awards

First-Team Academic All-America from the College Sports Information Directors of America

First-Team Academic All-District from the College Sports Information Directors of America

3 All-Academic awards from the U.S. Track & Field and Cross Country Coaches Association

RMAC First-Team All-Academic three times

FROM THE EMERGENCY ROOM TO THE TOP OF THE PODIUM

An Oredigger cross country and track & field star finds redemption with a national title

BY SAM BOENDER

A historic win was within reach for Dillon Powell in November 2021 at the 2022 NCAA Division II Cross Country Championships in St. Leo, Florida. The Mines Cross Country and Track & Field star had put together an impressive cross country season, securing both the Rocky Mountain Athletic Conference Championship and the NCAA South Central Region Championship earlier in the year. But nearly 8,000 meters into the 10K race for a national title, the finish line suddenly didn't matter.

Under the hot Florida sun with nearly 80 percent humidity, Powell felt heat exhaustion overcoming him and his lead slipping. As he charged up a hill, he tripped, crawled to maintain his momentum and ultimately tripped again before finally collapsing into the dirt.

"When Dillon went down, it was scary," said Head Cross Country Coach Chris Siemers. "I pulled him off the course at the top of the hill. My thoughts were all over the place, and I was focused on getting him medical attention."

Powell and many other competitors in the national race facing similar effects were taken from the course to the local emergency room for medical attention.

"I don't remember much of the race after 6,000 meters," said Powell. "I was comatose for about 20 minutes after being pulled from the course. My internal temperature was measured at 106.5 degrees Fahrenheit, which is up in the range of 20-50 percent chance of death. I am very lucky for those around me who got me cooled down and to the hospital."

But this scary experience didn't prevent Powell from returning to the sport. In fact, Powell was determined to accomplish the goals he and Coach Siemers had laid out at the beginning of the season: an ambitious list including a national championship, a national record and multiple all-America awards.

"The main lesson I learned from the cross country and indoor seasons was to be patient," said Powell. "In running, the last move is usually the one that wins, so being decisive and calm throughout the race is crucial. After the disappointment in Florida and coming so close to a national title in the 5K, I was very motivated and also very confident in Coach Siemers' training."

On the evening of May 26, 2022, at the 2022 NCAA Division II Track & Field Championships in Michigan, Powell finally found redemption. He executed the race strategy to perfection and cruised to nearly a 10-second victory to clinch the seventh national championship in Mines men's track & field history.

"I was in tears as he pulled away from the competition in Michigan," Siemers said. "To win that race, he had to put that awful day in Florida behind him. It means so much to his teammates as well because they run with him every day and he pushes them to be better. Even more so, we all know that he is a great person and a great student, and that's more important than winning."

"It was totally redemptive," Powell said. "It made all the bitter moments better. I realized what I had learned from my previous failures made me a better runner. In the race, I was far more patient. I keyed off other runners to a greater extent. With 1,300 meters to go, I put in a surge that I was sure would break the rest of the field and still kept pushing. I closed my last 1,000 meters faster than I had ever run outside of the 5K during indoors. I was kind of in a state of shock on the podium and for the next couple days."

The 2022-23 season will be Powell's final collegiate season. Even so, he has plenty of goals remaining, including USTFCCCA Cross Country All-America status and multiple individual and team national championships up for grabs.

➔ For more on Mines Athletics, visit minesathletics.com

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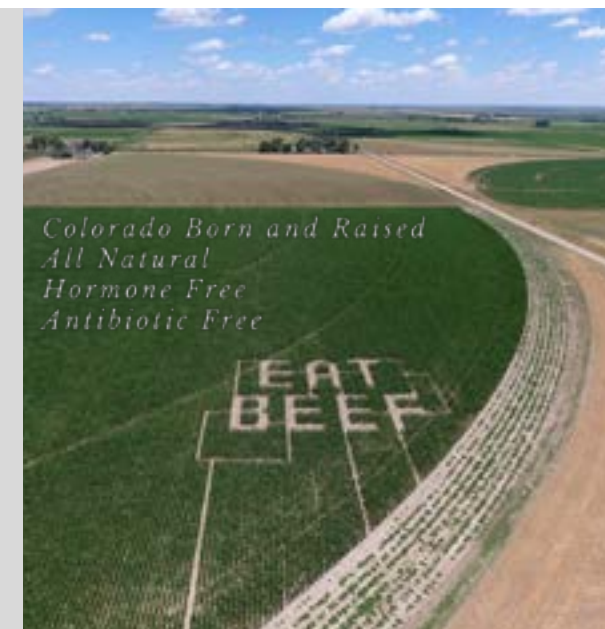
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Antibiotic Free*

CONNECTIONS

➤ More than 60 alumni from around the country tuned in to hear from new head football coach, Brandon Moore, at Mines' monthly Lunch Bunch program in July. ♦

CONCRETE SOLUTIONS TO INFRASTRUCTURE CHALLENGES

Mines researchers are improving construction materials with sustainability and performance in mind

BY SARAH KUTA

THE PROBLEM WITH CONCRETE

Concrete is the second-most consumed material in the world, second only to water. Used to construct buildings, roads, bridges, dams and many other pieces of vital infrastructure, this versatile material is everywhere. But its widespread use comes at a cost: By some estimates, the concrete production process is responsible for up to 8 percent of the world's carbon dioxide emissions.

THE SOLUTION INVOLVES SEVERAL KEY IDEAS: IMPROVING DURABILITY

Lori Tunstall, assistant professor of civil and environmental engineering, is developing novel methods of improving concrete to help lower its overall environmental footprint.

She's trying to help make concrete more durable so it can stand up to the punishing freeze-thaw cycle that exists in many cold climates, as well as other causes of degradation that, over time, cause concrete to crack, crumble and break apart. Concrete that lasts longer doesn't need to be replaced as often which, in turn, will help reduce the demand for the heavy CO₂-emitting production process.

To improve durability in the long term, she's studying the basic material science properties of existing air-entraining admixtures, which create air pockets that provide space for water to grow into ice crystals as it freezes within the concrete.

"There are still just a lot of unknowns in the concrete industry," she said. "We haven't



Lori Tunstall, assistant professor of civil and environmental engineering, handles a carbon-sequestering material called biochar.

Photo by Cyrus McCrimmon

investigated the fundamentals that control the processes because they've always just worked—it's one of those, 'if it's not broken, don't fix it' kind of things. But now that the admixtures are getting much more complicated, we're trying to understand the fundamentals."

WORKING SUSTAINABILITY INTO THE EQUATION

Tunstall is also addressing CO₂ emissions head-on by experimenting with incorporating biochar, the umbrella term for the carbon-sequestering material produced from biomass sources, such as wood chips and agricultural waste products, into concrete.

"With the incorporation of biochar into concrete, we're able to replace 15 percent of the cement with this biochar additive, and we estimate that will offset the carbon footprint of concrete by at



PhD student Cara Clements stress tests a sample of material made from mine tailings.

Photo by Cyrus McCrimmon

least 45 percent," she said. "It doesn't get us to carbon-neutral, but it gets us in that direction, so perhaps coupled with some of these other techniques, it could actually be a viable way to get us there."

DEVELOPING ALTERNATIVE CONSTRUCTION MATERIALS FROM MINE TAILINGS

With the renewed focus on infrastructure, there's also a greater need for construction materials across the country. Reza Hedayat, associate professor of civil and environmental engineering, is working to meet that demand while also reducing the environmental impact of another industry: mining. In collaboration with Mines' Center for Mining Sustainability, Hedayat is exploring how to reuse leftover minerals from mining operations in bricks, tiles, aggregates, ceramics and concrete additives. His research has the added benefit of helping the mining industry reduce the environmental and economic impact of the 10 billion tons of waste materials, also known as tailings, it produces every year.

EVALUATING EXISTING INFRASTRUCTURE

Before they begin replacing America's existing infrastructure, engineers and construction crews first need to evaluate it—and, to do that, they need practical, cost-effective techniques that don't damage

the structure or delay its operation. Hedayat is also innovating on that front. By designing and conducting highly controlled experiments, his group is investigating what's happening inside materials and structures at various points in time—without damaging them in the process.

For example, he collaborated with Kiewit Corporation to evaluate and test different methods of detecting potential voids caused by water washout in the grout behind concrete segments of tunnels being built in New York, a process that historically involved drilling verification holes. Thanks to his findings, on-site construction engineers were able to use ground-penetrating radar, which emits an electromagnetic wave pulse and measure the return time and strength of the reflection, to ensure the safety and stability of their projects.

"In some environments, there is a high potential for the grout to wash out behind the tunnel segments that would compromise the integrity of the tunnel support system," he said. "Detecting the voids behind the segments allows the tunnel contractor to perform secondary grouting and fill any remaining void spaces. The assessment is important to ensure proper support of the tunnel and the ground around it."

CONNECTIONS

► Several Mines alumni volunteered at Oredigger Camp this year to help welcome new Mines students into the Oredigger community. ♦

► John Bradford was the featured speaker at the August Lunch Bunch event to discuss the Global Energy Future Initiative. ♦



Photo by Cyrus McCrimmon

TEACHING ROBOTS HOW TO THINK AND SHARE INFORMATION BY ASHLEY SPURGEON

Machine-learning models help improve manufacturing processes in real time

Many manufacturing processes today rely on 3D-printed methods and machine learning to produce high-quality products at a faster rate. This requires machines that can evolve and improve over time through learned experience. But getting machines to share knowledge is easier said than done.

We asked Xiaoli Zhang, associate professor of mechanical engineering, to tell us more about how machines can learn and share knowledge to improve manufacturing processes. This is what she shared.

TRAINING MACHINES IS LIKE TEACHING HUMAN BABIES.

When 3D printing a part or product, most of the quality control, such as determining the hardness of the printed material, is completed after the part has been completely manufactured. But Zhang is developing process-structure-property (PSP) machine learning-based models to identify defects in real time to avoid failures and save time and money.

To get a machine to successfully adopt a PSP model, researchers feed it data, and the machine-learning techniques will explore that data to build PSP correlations on its own. Scientists approach this in a similar way that humans teach babies to recognize the differences between images of cats and dogs.

When babies are given images of cats and images of dogs, they can quickly learn to distinguish them—something machine-learning models need to learn as well.

“We give the data to the machine learning algorithm, and we provide it with a ground truth—we tell the computer the correct answer at the beginning of the training,” Zhang said. “Just like a baby can figure out the difference between a cat and a dog quickly, the computer machine-learning algorithm will also learn how to distinguish them given the ground truth. This way, once a machine-learning algorithm is trained, it will be able to conduct defect classification or quantification

tasks, even the given data that are different from the original training data, just like a baby can differentiate new cat images from dog images.”

Once a machine understands these ground truths and the parameters needed to successfully print a part or produce a product in a specific way, it can make adjustments in real time and avoid mistakes during the characterization process, eliminating the need to complete post-characterization tests to determine the quality of the product.

GETTING MACHINES TO LEARN FROM EACH OTHER REQUIRES A SHARED BRAIN.

The next step in improving additive manufacturing processes is getting the machines to communicate and learn from each other without humans having to upload data to individual machines. Zhang has a solution that was also inspired by humanity: a system that functions similarly to how humans share knowledge via the internet.

“In terms of the machine knowledge transfer, once we have a model in one printing machine, we want to transfer that to another one,” Zhang said. “Think about

how we develop our human world—we learn from each other and share through the internet. Machines can also have their internet with a cloud-based system. Each machine can post its data and knowledge, run it through the cloud and then it can be assigned to every machine in communication with the cloud. Then they can share and learn from each other.”

When a machine uploads a PSP model to the cloud, other machines on that same system can access that model, learn the specific parameters required to produce a part and successfully print the product with the desired characteristics. Humans wouldn’t need to manually upload data or teach individual machines how to make the appropriate correlations from scratch. This interconnectivity and shared knowledge can help manufacturers scale up the number of products and capability for mass production, cut labor costs and decrease production time.

“I imagine we will have less and less labor work to do the monitoring and post-characterization, but that doesn’t mean it’s a negative,” Zhang said. “We can produce products faster, and then the overall workforce development may grow.”



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 **COLORADOSCHOOLOFMINES** For more information, go to plannedgiving.mines.edu

CONNECTIONS

► Heather McKay '06, MS '07 was featured on *Colorado Matters* to talk about NASA's Artemis missions and the future of space exploration in August 2022. ◆



BRIDGING THE INTEROPERABILITY GAP IN CITIES

Standardizing building semantics will help improve efficiencies and performance

BY ASHLEY SPURGEON

We often see it in science fiction films: entire cities that operate with an interconnected ecosystem of smart technology that seamlessly shares data to communicate across a vast network of devices and platforms to maximize efficiencies. These “smart cities” enable a wide array of capabilities that the average person doesn’t even have to think about on a day-to-day basis, such as transportation and access to essential resources. Implicit in this vision is the idea

of interoperability—the ability of disparate technologies and systems to interact with one another.

But while we don’t yet live in that sci-fi ecosystem, researchers are working on ways to make that a reality, but integrating this interoperability is more complicated than you might think. It all comes down to semantics.

To use data to understand a large area of an existing built environment, such as cities,

buildings and transportation systems, having a good digital representation of that system is necessary. “We need a metadata model, which is a digital description of how the system is put together, how it works, what devices are there and what data they produce,” said Gabriel Fierro, assistant professor of computer science.

Buildings are responsible for 40 percent of the energy consumption in the U.S., so they are a particularly rich target for innovations in energy management. However, there isn’t a standard way for describing building systems. Many older buildings have no digital description, and while many modern buildings contain Internet of Things systems, the lack of a standard means that computers aren’t able to interpret that data effectively. Fierro is working on a project to change that by developing a standard way of describing buildings and their data to make it easier to develop software for them.

Fierro said the key to modeling a complex system in a consistent way is to figure out which details matter and which don’t—similar to how you can plug any keyboard, mouse or monitor into your computer and it will still work regardless of what kind of processor or operating system you have.

“I can write the software once and then deploy it for millions and millions of buildings and get the same benefits as if an expert had been there to curate the experience for each building,” he said. “Having these consistent digital descriptions of this infrastructure makes it possible to provide management in a more distributed fashion without having to involve experts at every level. The software can essentially configure itself to run in a new building without any human intervention, similar to how an automatic car knows how to shift gears at the right time without the driver having to know when to move it back and forth.”

This semantic interoperability would allow for easier software development to provide better energy efficiency, optimize system performance and automatically identify and diagnose faults. This lowers costs for building owners who buy the software, as well as the developers who create it.

Fierro said, “Going forward, I hope to see critical physical infrastructure adopt more modern data management practices so we have greater insight into how these systems are operating. Eventually it would be interesting to explore the idea of municipal data as a public utility.”

Hiring and HR Experts in Mining & Green Energy

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Your people & project solutions
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CONNECTIONS

- ▶ David Lawler '90 gave the keynote presentation at the Global Energy Future Innovation Forum in September 2022 to showcase Mines' ground-breaking research in creating a net-zero energy future. ◆

A LOOK BELOW THE SURFACE

BY SARAH KUTA

In the past century, the field of geophysics has only grown—and continues to gain importance in understanding the Earth's subsurface

As a child, Whitney Schultz '17, MS '19 remembers always being fascinated by rocks, a passion her geologist mother encouraged whenever they went on hikes or other outdoor adventures near their home in Parker, Colorado.

"I would collect pieces of muscovite and biotite, and my mom would point out different minerals in rocks I picked up," said Schultz.

As she got older and began immersing herself in science and math, she never let go of that early love of geology, but she realized there was more going on beneath the Earth's surface than meets the eye. And when she got to Mines and learned she could investigate and measure those subsurface conditions, Schultz was hooked. Geophysics became her clear path forward.

Today, she works as a geophysicist for the Houston-based energy company Oxy, interpreting seismic data in hopes of finding hydrocarbon deep underground.

"I can see geology and data from around the world, all in one place," said Schultz. "When you really think about the scale and the time it took to form them, it's just fascinating. It's very humbling, to say the least. We're talking about geologic time—millions of years."

She's one of the many skilled Mines graduates working in this small but in-demand field, which is expected to grow by 7 percent by 2030.

And while many up-and-coming geophysicists will continue to do the vitally important job of supplying the world with energy and minerals, others will put their expertise into practice in an array of diverse roles, from finding new sources of water to monitoring climate and critical infrastructure and even exploring other planets in the solar system.

Mines students measure geothermal activity during the geophysics field session in Steamboat Springs, Colorado.

“At Mines, we want to focus on things that have societal importance, and the field of geophysics is directly relevant to a whole spectrum of applications that have meaning to many people all over the world.”

—PAUL SAVA, GEOPHYSICS DEPARTMENT HEAD

For the future of geophysics, not even the sky is the limit.

“Students care about exploring our world and making a contribution—they care about the environment, they’re curious about the oceans, they have ambitions to go out into space,” said Paul Sava, who leads Mines’ geophysics department. “At Mines, we want to focus on things that have societal importance, and the field of geophysics is directly relevant to a whole spectrum of applications that have meaning to many people all over the world.”

GEOPHYSICS: PAST AND PRESENT

In 1926, Mines became the first university in the world to launch a standalone geophysics department when a group of academics got together to pursue novel methods for finding underground natural resources. The Society of Economic Geophysicists, now the Society of Exploration Geophysicists, formed not long after in 1930.

“The original thinking was that the field of geophysics would evolve in its own direction because it was intrinsically linked with emerging technologies,” said Sava of Mines’ pioneering geophysics researchers. “The main distinction between geology and geophysics is that, in geophysics, we do not interact directly with the object of study, be that the Earth or some other planetary body. Instead, we take measurements from the outside of this object of different physical fields, and then through math and computing, we create an image of that interior structure, just like in medical imaging.”



Students set up hammer seismic survey during the 2022 geophysics field session.

At that time, geophysicists were developing and using new cutting-edge techniques for exploring subsurface natural resources. As the field advanced throughout the 20th century, geophysicists continued to partner with the oil and gas industry to ensure the world had access to power and fuel, as well as the mineral resources needed to advance our technological society. To this day, many Mines geophysics graduates go on to work for energy and minerals companies.

“We are providing a necessary resource,” said Mandy Schindler PhD ’18, who works as an exploration geophysicist for Shell. “The demand for energy is still rising with the growing world population. We all know we need to move away from fossil fuels in the long run, but that’s going to be a gradual process—we’re still very much dependent on them. And it’s a resource that’s needed to make sure people can have the standard of living they deserve.”

In more recent years, the field has expanded to include a vast array of other applications, some of them surprising. Geophysical techniques can help predict and quantify natural hazards, including tsunamis, earthquakes, landslides and volcanic eruptions. Researchers in the field are also using geophysics to study glaciers, oceans and the atmosphere to draw inferences about the evolving Earth climate, as well as explore planetary bodies such as moons, asteroids, comets and other planets.

And as the global population continues to increase, geophysicists are also being called upon to search for and monitor groundwater, an application that’s likely to become crucial in the future.

“We are already witnessing dramatic changes in water distribution—we see it here in the West, and it’s having an enormous impact,” said Sava. “We see humongous lakes that are shrinking dramatically. And that poses the question of, well, how do we access water? Where’s the water, and, if it’s underground, how much is there? Can we access it, and how?”

Above all else, geophysical techniques help solve problems.

“Ultimately, planet Earth is our home,” said Sava. “The greatest technology and the greatest engineering don’t actually mean a whole lot if we can’t breathe, we can’t eat, we can’t drink and we don’t have a harmonious relationship with our home. That’s why understanding our home is something that should be of concern to all of us. Geophysicists are the people who keep their finger on the pulse of the planet, but this is of relevance to all of us.”

TECHNOLOGICAL ADVANCES LEAD THE WAY

Novel applications aside, technological advancements are also moving the field forward in new ways. Researchers are now realizing that fiber optic cables—

installed underground to bring high-speed internet to homes and businesses across the globe—can also gather geophysical data nearly continuously. Satellites, too, may be able to provide a constant stream of information about the Earth while orbiting the planet.

Sava compares these types of technological advancements to smartwatches: Whenever a person is wearing one, the device is monitoring and recording various aspects of the body's functions for long periods of time, often without the wearer even noticing.

"We'll have many more sensors that are active for much longer—we are not going to go to a place, take measurements and leave," he said. "We'll instrument the space of interest and monitor it permanently. We can continuously listen to the planet in meaningful ways."

As an earth scientist for Chevron, Ivan Lim Chen Ning PhD '19 is one of the pioneering professionals putting these new technologies into practice. He uses fiber optic cables, via a technique known as distributed acoustic sensing, to help the company's engineers keep tabs on important metrics such as the structural integrity and flow rates of oil wells.

"The demand for energy is still rising with the growing world population. We all know we need to move away from fossil fuels in the long run, but that's going to be a gradual process—we're still very much dependent on them. And it's a resource that's needed to make sure people can have the standard of living they deserve."

—MANDY SCHINDLER PHD '18

Outside of the energy sector, Lim said, researchers are also now using underwater fiber optic cables to detect earthquakes and tsunamis, which could help improve warning systems around the globe. Scientists are even using it to eavesdrop on whales, which lets them learn more about the massive marine mammals' behavior.

"Just when we think we're already getting the most out of it, there's always a new application that spins out of the data we acquire," he said. "It's a rapidly evolving field."

LOOKING AHEAD

As the field grows and evolves, Mines continues to be a leader in geophysics innovation, especially when it comes to educating the next generation of professionals who can help society overcome its challenges.

At Mines, professors and instructors teach students the fundamental skills of geophysics—including a deep understanding of math, physics, computing, geology and engineering—then encourage them to pursue rewarding career paths in a variety of areas.

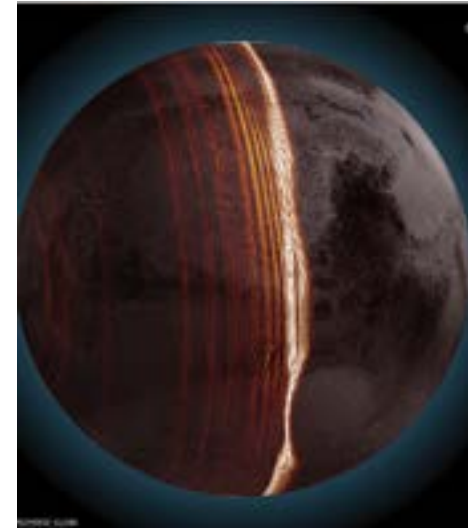
The overarching philosophy is to build a strong technical foundation, then keep an open mind about applications.

These days, geophysicists can use their expertise to monitor the world's changing ice sheets and glaciers, help archaeologists unearth historical structures, monitor evolving urban

Geophysicists use ground-penetrating radar to investigate ground-ice and groundwater interaction in Alaska.



Photo courtesy of Matt Siegfried



"Geophysical techniques are applicable to just about any scientific question we have that involves using physics to get insight into the interior of the object of study."

—BRYCE SWINFORD '07

This image of Mars shows seismic wave simulations from a 3D global wave propagation solver. The snapshot highlights the effect of the distinct crustal dichotomy between the southern and northern hemispheres, specifically on surface waves.

Photo courtesy of Daniel Peter (KAUST), Erbu Bozag and Quancheng Huang

environments and even ensure that materials used to build airplane wings are free from defects, for example. Geophysicists also support homeland security and national defense efforts by detecting landmines and illegal underground structures. They can ensure that dams are structurally sound and study the potentially devastating effects of solar flares on the power grid. Geophysicists even go work for NASA, which sent a seismometer onboard the InSight lander to measure the internal activity and "marsquakes" of the Red Planet.

"I like that the field can tell us so much about our planet and other celestial bodies without damaging anything," said Bryce Swinford '07, who works as a senior geophysicist for Oxy. "And all our techniques are scalable: The same principles that let us look at things on a planetary scale can be used on something the size of a bowling ball or a human skull. Geophysical techniques are applicable to just about any scientific question we have that involves using physics to get insight into the interior of the object of study."

Geophysicists will undoubtedly help with the energy transition, too, such as by identifying appropriate off-shore locations for windmills or searching for promising new stores of lithium and other minerals needed to create more batteries for electric vehicles and other devices. They'll also help communities tap more into new sources of sustainable energy, such as the geothermal heat produced deep in the Earth's core.

Already, they're helping leading oil and gas companies figure out how to capture and sequester carbon dioxide, which accounts for 79 percent of the nation's greenhouse gas emissions from human activities. Geophysicists can employ some of the same techniques used to find oil and gas to explore potential underground reservoirs for CO₂ storage, which may help remove some of the heat-trapping gas from the atmosphere.

The possibilities for this field are seemingly endless, and according to Schindler, "We will find our place as geophysicists."

THE SUPERPOWERS OF GEOPHYSICS

Geophysics is a truly multidisciplinary field that draws on principles from math and physics, computer science, geology, electrical engineering, math, physics and other areas of study.

Using an array of different techniques and tools, including seismic surveys, ground-penetrating radar, gravity investigations, electric and magnetic mapping, geophysicists gather tons of data about the subsurface of the Earth (or another planetary body or structure). Then, they interpret these data to help achieve a goal, such as predicting dangerous natural hazards and climate evolution or finding valuable troves of oil and gas, minerals, water and other valuable resources.

To capture the imaginations of prospective students, Paul Sava, geophysics department head, likes to compare geophysics to medical imaging. In hospitals and clinics around the world, doctors can safely and painlessly investigate mysterious illnesses and identify unknown ailments deep inside the human body with the use of safe and noninvasive imaging tools, such as magnetic resonance imaging (MRI) and X-ray tomography. Geophysicists have a similar goal and use analogous tools but for the study of Earth or other planetary bodies.

Another favorite analogy? Superhero powers.

"Sometimes I talk about superpowers, the ability to see inside and through walls," he said. "That's the kind of thing we do: We look inside the Earth. Just walking on the surface, you don't know what's deep down there, but by taking clever physical measurements then processing and interpreting that information, suddenly, you have a superpower—geophysics."

THE IMPACT OF THE BUILT ENVIRONMENT

Fulbright scholar is learning how to build livable communities, for everyone

BY ASHLEY PICCONE

Like countless people in 2020, Peyton Gibson '17 felt locked away and stifled by the COVID-19 pandemic. But unlike many others, she harnessed those emotions and poured them into a lengthy and arduous application: a scholarship for the Fulbright Program, the U.S. government's flagship international educational exchange program.

Gibson's interest in the prestigious program came when her Mines background and passions collided. As a Mines student, she studied civil engineering and led a chapter of the American Society of Civil Engineers. Afterwards, Gibson worked at the National Academies of Sciences, where she contributed to a broad range of built-environment policy projects.

"I was pretty familiar with the technical side of things because of my time at Mines," she said. "But I was also working with a lot of economists, which got me interested in studying how both economics and engineering can be used to build a better world."

In April 2021, Gibson was awarded the Fulbright scholarship to study at Vrije Universiteit Amsterdam in the Netherlands. She handpicked the institution because of its spatial economics program, which uses data analytics and econometrics to understand how where people live and work affects the quality of their lives.



Photo by Tulip Sujeera

"I really wanted to explore how the things we build and design impact the people they are actually made for," said Gibson. "I originally wanted to study civil engineering because I wanted to give everyone a chance to thrive in a livable community. I think the U.S. has a long way to go, in terms of building communities that create good health, socioeconomic and environmental outcomes."

Gibson moved to the Netherlands in August 2021, meeting students from across the world and learning to consider viewpoints stemming from different cultural experiences. The Netherlands' stellar infrastructure, with the ability to bike or take a train almost anywhere in the country, proved ideal for Gibson's research and taught her how to evaluate what is working and what can be improved.

"The way the Dutch are collecting data—the government organizations they have put together to analyze the data of the policies that they are

"I REALLY WANTED TO EXPLORE HOW THE THINGS WE BUILD AND DESIGN IMPACT THE PEOPLE THEY ARE ACTUALLY MADE FOR."

implementing—those are things I think the U.S. should strive to do," she said.

Gibson defended her master's thesis in August 2022, but for now, she remains in Amsterdam working as a consultant for Autodesk, a company focused on design and make technology. As one of their newest employees, Gibson is working on creating a social impact service that will allow customers to measure the ways their infrastructure they build and design affects the communities around them.

But if she's learned anything during her time abroad, it's to keep plans fluid and open to new possibilities—both in terms of the built environment and in her personal life.

"If I look at my journal entries from five years ago, I remember making a two-year plan, five-year plan, 10-year plan," she said. "Those are great to have, but I don't think I could cross anything out. I've learned to keep my mind open and be willing to go for new opportunities."

SHERIDAN ROSS PC ATTORNEYS AT DIFFERENT PERSPECTIVES



Patent



Trademark



Commercial Litigation



IP Litigation

CONNECTIONS

► In September, the Mines Aerospace Interest Group and American Institute of Aeronautics and Astronautics held the Trajectories 2022 event with panels of experts discussing how previous aerospace missions are informing future endeavors. ▲

EXEMPLARY MINES ALUMNI

Recognizing the 2022 Mines alumni award winners

Each year, Mines honors exemplary alumni for their dedication to the university, the alumni community and their local areas. This year's alumni award winners include Orediggers who have helped support and strengthen the Mines community in the last 12 months and beyond.



Robert Zimmerman '86

MELVILLE F. COOLBAUGH AWARD

Given to an individual who has made an outstanding contribution toward improving the image and enhancing the reputation of Mines.



Alejandro Garcia, Class of 2023

ALUM OF THE FUTURE

Given to a student for his or her efforts in strengthening the Mines Alumni Board or one who embodies the spirit of the Mines Alumni Board.



Steve Enger '81

OUTSTANDING ALUM

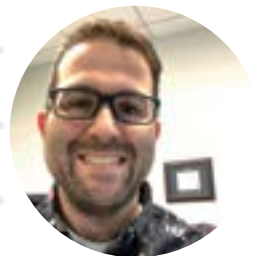
Recognizes an alum who has contributed meritorious service.



Tisi Igogo MS '17, PhD '19

YOUNG ALUM

Given to a young alum whose accomplishments have reflected favorably on Mines (the alum needs to have received his or her degree no more than 15 years prior to the date of the award and is not older than 40 years of age at the time of the award).



**Anthony Bordonaro '12
M Club Midland**

M CLUB LEADER OF THE YEAR

Recognizes Mines alumni who are M Club leaders in their area and go above and beyond to support Mines and fellow Orediggers.



George Sturgis '78

ALUMNI ACADEMIC INVOLVEMENT AWARD

Given to a member of the Mines community who goes above and beyond to support the rigor of a Mines education.

You create the whole engineer

Orediggers rely on an interconnected community of support.

You help enrich the student experience outside of the classroom through your generosity. Students who participate in co- and extracurricular activities, such as clubs, intramural sports, fraternity and sorority life, student government, professional societies and music programs, perform better in the classroom and are more successful in their careers.

You can help foster well-being, as well as personal and professional growth for students, like Ashwini Shrestha.



“Extracurricular activities are essential to my Mines experience—from building my leadership skills to developing a strong sense of community and Oredigger pride. I am grateful to be able to balance my challenging courses with my involvement as Homecoming chair for the Mines Activities Council, secretary for Mines Without Borders, an event lead for KickStart Experiential Diversity Club and a peer mentor for the NeST Office.”

—Ashwini Shrestha, Class of 2025



Academic Success

- Offer tutoring and advising services that increase personal and career success
- Enhance communication and professional skills
- Spark problem-solving collaborations
- Inspire student-led innovation and entrepreneurial thinking



Student Life

- Sustain Oredigger traditions like the M Climb, Oredigger Camp, Homecoming and E-Days
- Bolster Mines' living-learning programs and environment
- Offer immersive leadership opportunities
- Support student retention and promote grit and resiliency

CONNECTIONS

- ▶ Mines alumni participated in the fall Career Day event to engage with representatives from hundreds of companies and learn about their industry involvement. Following the event, they gathered for an alumni happy hour at Mountain Toad Brewery. ▲





AN ACE OF A FUNDRAISER

The chairman of the Golden golf tournament works hard to help students thrive

BY ASHLEY PICCONE

Every spring, more than one hundred people gather in Golden, Colorado, for a round of golf. When they arrive, they check in, grab a breakfast burrito and head out onto the links. On courses in Houston and Oklahoma City, a similar scenario plays out.

Each of these golfers, who are Mines alumni or from sponsoring companies, plays to support Mines and its students. The annual Mines Alumni Golf Tournament began in Golden 38 years ago and spread to Houston 16 years later. Originally organized as an alumni fundraiser, the event now contributes to an endowment that provides funds for Mines student scholarships. In 2021, 12 scholarships were awarded, totaling nearly \$50,000. This year, the tournaments are on track to raise more than \$90,000.

As the golfers play out their holes, they socialize with volunteers running the tournament, like Paul Pastore '89. Pastore has been the Golden Endowed Scholarship Golf Committee chairman for the last four years, first becoming involved in the event as a player.

“When the committee gets together to plan this, it’s just fun. We have great camaraderie, we have a few laughs, we talk about how we want to make a

difference,” Pastore said. “It’s really nice with a bunch of people I’d call friends coming together. We have many, many great volunteers and Mines Foundation employees that make it successful. And we’re always looking to add more.”

Pastore began volunteering for the fundraiser because of a strong belief in giving back to Mines, an institution he says he was privileged to attend.

“MINES HAS AN EXCELLENT TRADITION OF SENDING STRONG, CAPABLE ENGINEERS OUT INTO THE WORKFORCE. I TRY TO UPHOLD THAT TRADITION. IT HAS ALWAYS BEEN A SPECIAL PLACE TO ME, AND I AM PROUD TO HELP NEW STUDENTS BECOME PART OF THE MINES COMMUNITY.”

“Mines has an excellent tradition of sending strong, capable engineers out into the workforce. I try to uphold that tradition,” he said. “It has always been a special place to me, and I am proud to help new students become part of the Mines community.”

But what really sealed the deal for Pastore was speaking with the scholarship recipients and learning about the tournaments’ impact firsthand.

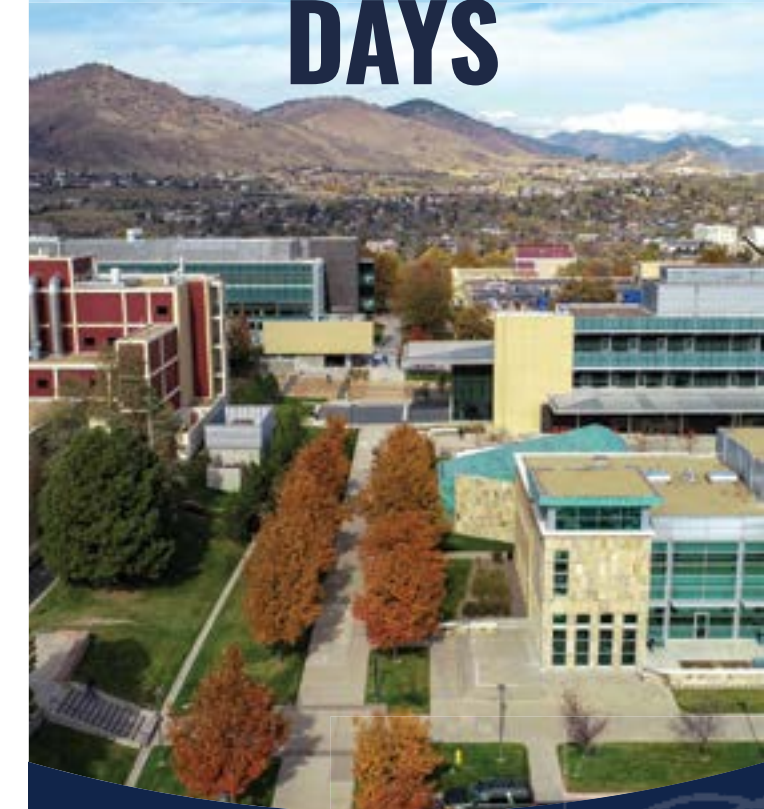
“When I met with a 2021 scholarship recipient over lunch, he communicated that he just simply wanted to thank everybody who has participated in the tournaments, who contributed to making his dreams come true,” he said. “Hearing that put it all in perspective for me, you know? You just need to make a difference in whatever you do.”

At the end of the Golden tournament, after the golfing wraps up, the participants gather for lunch and are handed a coin that was made at the Mines foundry. Throughout the year, Pastore, other volunteers, and players ask each other where they keep their coins. The simple tradition simultaneously reminds them of the fun they had and the people they’ve helped—not to mention how they can improve their swings for the next year.

SAVE THE DATE



SPRING CAREER DAYS



Feb. 7 & 8, 2023 (in-person)

Employer registration opens mid-October.

Due to high demand, Mines Career Days has expanded. For more information, contact Career Center Director Wendy Winter-Searcy at wwintersearcy@mines.edu or 303-273-3235.

CAREERS.MINES.EDU



COLORADO SCHOOL OF
MINES

CONNECTIONS

- ▶ President Paul C. Johnson and the Mines campus leadership team held a State of Mines webinar in September 2022 to share a bit about the Class of 2026, campus growth and introduce the new vice president of student life. ◆



ENGINEERING AN URBAN FARM

Mines alumni put their entrepreneurial skills to work with Wild Wick's Farm

BY ANICA WONG

Jamie '07 and Doug Wickler '07 could be sitting in offices with lucrative careers as civil and mechanical engineers, respectively. Instead, they are watching their two young kids running around their urban farm in Lakewood, Colorado, picking (and eating) strawberries.

"We wanted to spend a lot of time with our family, and working the 9 to 5 didn't fit into that," said Doug. "So, the entrepreneurship piece comes with trying to figure out how to include our family in the business, even our little kids."

HOW TO START AN URBAN FARM

The Wicklers own Wild Wick's Farm, about a half-acre of growing space split across four properties. They sell their produce at two local farmers' markets during the summer and have a 20-person Community-Supported Agriculture system, which provides produce every week to customers who purchase a share at the beginning of the season.

Jamie has been farming for 11 years with various organizations, including the Denver Botanic Gardens' Chatfield Farms, where she developed and taught a program for veterans interested in agriculture. Jamie's background, combined with Doug's handiwork skills and desire to move out of a government job where he was using a lot of harsh chemicals on plants, created a perfect opportunity for them to start farming together. They've been doing that full-time for two seasons.

The Wicklers are in the exact spot they want to be at a time when it has become critical for all people to be involved in our food systems: stewarding the land, providing food to their community and constantly considering how to update their systems and processes to do those things as best as they can.

That is where their engineering background comes in.

"Using my Mines degree to problem-solve soil is a little bit different from what I was doing as a civil engineer," said Jamie. "Chemistry, biology, physics—those are all things that you need to know in order to farm. Plus, I got a minor in economics, and Mines prepared us significantly in the numbers game. Understanding how cost, profits and interest work is important to running your own business."

The cornerstone of the Wicklers' business model is sustainability. Jamie talks about it in an economic sense: How do they make sure the farm is financially sustainable as they continue on this entrepreneurship path? For them, it means thinking creatively. For example, buying a large piece of land to exclusively farm on was out of their budget, so they slowly purchased rental properties in and

around Golden (which they often rent to Mines students) and converted the yards into growing spaces.

That sustainability focus also extends to caring for the environment. They don't use synthetic fertilizers, pesticides or herbicides—as Doug points out, the best pesticide is a healthy plant, which starts with diverse, strong and complex soil. Utilizing organic practices is incredibly time and labor intensive, but it's the only way the Wicklers want to steward their land and grow as much food as they can. "Food is medicine," Doug said.

EDUCATION REMAINS AT THE FOREFRONT

The Wicklers also emphasize educating the community at farmers' markets and other outlets about their growing practices, because it highlights what makes local food so special.

"People who buy our produce love the flavors that they can't find at the grocery store," Doug said.

The Wicklers also serve as mentors to other local farmers. They help farmers set up irrigation systems and plan sustainable greenhouse construction. They provide support and expertise when farmers are trying to balance their soil. They are always around to lend an ear or troubleshoot pest problems.

"There are many barriers to becoming a farmer, so we have been incredibly fortunate to have Jamie and Doug just a phone call away," said Ivan Soto of SoCliff Farm, another urban farm in the Denver metro area. "They have provided guidance on issues we've never dealt with before, and they've cheered us on. Like many others, they welcomed us into the local farming community, and we're grateful for their support."

While Jamie and Doug farm to do right by the land they grow on, connect with people and be their own boss, they also point to two small faces smeared with strawberries as their main driver.

"I want our kids to see this community that's coming together around food and talking about sustainable food and how important that is," Jamie said. "I want them to know that this hard work means something."

CONNECTIONS

► Mines Petroleum Engineering students traveled to Midland, Texas, for their summer field session and attended a mixer with local alumni to connect over their shared Oredigger experiences. ▲

► President Paul C. Johnson and Foundation President and CEO Brian Winkelbauer traveled to Durango, Colorado, in summer 2022 to meet with Mines alumni and share what's in store for the academic year and the Campaign for MINES@150. ▲

THE COMMERCIALIZATION OF SPACE

Space mining is the next Gold Rush but requires navigating intellectual property laws

BY ANNA SQUIRES

When the first gold flakes appeared in the Sacramento Valley in early 1848, the discovery sparked the American Gold Rush faster than a gasoline fire. But the next great rush for precious metals will take place much farther than California: outer space. And it will happen soon.

“This is the Wild West,” said Deborah Peacock ’78, president of Peacock Law P.C., the largest intellectual property firm in New Mexico, which specializes in legal issues within the spaceflight and aerospace industries. “It is a space race.”

Peacock’s law firm represents clients all over the world who are pursuing extraction and mining technologies in space. And similar to the late 19th century, this new rush for mining claims promises to be challenging, both technically and legally.

Some of those challenges arise from the few existing laws that regulate commercialization beyond Earth.

When a spacecraft launches from Earth, Peacock explained, it is subject to the laws of the country from where it launched, including patent law. Companies can take

advantage of the regulation by registering a space-bound object in a country where the invention has not been patented, thus sidestepping its owner’s intellectual property rights. Peacock spends much of her time working with clients to ensure they are protected with intellectual property agreements filed in every country with a launch site.

On a larger scale, the policies in place to prevent Gold Rush-style disputes over mining claims are also worryingly out of date. “As patent attorneys, we work in the future,” Peacock said. “But since the Outer Space Treaty was signed in 1967, space law hasn’t changed much.”

That treaty, which still forms the basis of international space law 55 years after it was written, has critical gaps.

“Under the Outer Space Treaty of 1967, no country is allowed to

appropriate objects in outer space,” Peacock said. “But the signatories didn’t know that private companies would one day be doing that. And that’s really where we’re headed: private space.”

More recent agreements, like the 2020 Artemis Accords, have failed to unite space-going nations. In addition to returning humans to the Moon by 2024 and establishing a crewed lunar base by 2030, the Accords created a code of ethics for future space exploration—asking signatories to promise to be “good neighbors” by keeping space operations peaceful and sustainable. But Russia and China, two of the world’s most prominent spacefaring nations, have refused to sign the Artemis Accords.

The gaps in current policies essentially form loopholes for private companies to race to the Moon in pursuit of its “nearly unlimited” resources, including rare



earths, volatiles, Helium-3, titanium and platinum. Their value, Peacock said, will likely incentivize a rush to stake mining claims on the Moon, because they have the potential to revolutionize space exploration and habitation. Even the Moon’s water and ice are valuable; they can be electrolyzed to form hydrogen and oxygen propellant, allowing rocket fuel to be processed in space.

And thanks to these critical gaps in policy, the Gold Rush-era reality of mining claims—staked on a first-come basis and over which disputes were solved with violence—may not seem far-fetched.

Peacock, however, believes that most space-going nations will stay civil. “Most of the space nations are fairly responsible countries,” she said. “They may not agree with each other, but they’re responsible for their own activities.”

And although much of the existing regulation is in place on a country-by-country basis, the U.S., for instance, is “regulated in almost every way, including in space,” Peacock said. Ten or more agencies must give permission for spacecraft prior to launch and regulate everything from licenses for launch and re-entry to space debris.

“AS PATENT ATTORNEYS, WE WORK IN THE FUTURE.”

One thing that seems certain, Peacock said, is that the race to mine asteroids and celestial bodies—and the exploration it could fuel—will happen much sooner than she once thought. In 2017, Peacock predicted that mining and mineral processing would reach the Moon in the next 20 years. Now, she predicts it will happen in five.

But, Peacock admitted, “I’m an optimist. I believe there’s a really bright future for outer space. We need to become independent of Earth eventually, just in case. That bright future could include many colonies and many space ventures.”

Above all, she urges Mines students to take advantage of educational opportunities in the field, especially through Mines’ Space Resources program—the first in the world to focus on education for the growing space resources field.

“Outer space is no longer just for aerospace engineers, astronomers and physicists. It requires expertise in everything from artificial intelligence to public policy and law,” Peacock said. “If you are interested in outer space, there is a way to be involved, no matter what your degree and expertise.”



Makenna Green,
Class of 2023
Student Philanthropist

Justin Dvorak '16
Young Philanthropist
Award

Derek Morgan, PhD,
Dean of Students
Faculty & Staff Philanthropist

Bill Zisch '79
Volunteer of the Year

ARCS Foundation
Foundation Philanthropy Award

Don '55 & Lois Thorson
Tourmaline Award

CONNECTIONS

► The Mines Alumni Office hosted the first tailgate of the Oredigger football season in September 2022 in Allendale, Michigan, for local alumni to cheer on the team and celebrate the first game of the season. ♦



A SUPPORTIVE KICKSTART FOR BUSINESS VENTURES

Mines helps students navigate entrepreneurial pursuits with real-world resources and an encouraging community

BY ASHLEY SPURGEON

Many Mines alumni start their own businesses at some point in their careers, often drawing on the skills they gained at Mines to help them get their companies off the ground and find success in a competitive business market. Now, Mines is doubling down on those skills with more entrepreneurship and innovation opportunities for students to pursue during their time on campus to get a head start on building businesses, creating products and working with real-world investors to help their ideas become a reality.

For Trevor Bachand '22, deciding to cofound a startup was a scary but rewarding process, and it was Mines' available resources and support that helped guide him through starting and running a business. He was able to learn from and lean on a community of entrepreneurs—and even got a dedicated space to pursue ideas.

We sat down with Bachand to learn more about his entrepreneurial journey and the support he found at Mines to help kickstart his business. Here's what we learned.

A CORPORATE CAREER PATH WASN'T FOR HIM, AND FOUNDING A STARTUP BETTER ALIGNED WITH HIS PERSONAL VALUES AND AMBITIONS.

As Bachand worked toward completing his bachelor's degree in electrical engineering, he accepted a co-op with ExxonMobil. He loved the hands-on work in the field, but he soon realized working for a large corporation wasn't his ideal work environment. Near the end of his co-op, he was introduced to Ashwin Datta, an environmental engineer with an idea for a company called Instinct Environmental that uses data science to improve land and natural resource management.

"I like being outside," Bachand said. "My job right now is being an electrical engineer who spends a decent time in the woods messing with sensors and working toward the goal of better managing and maintaining places I care about."

STARTING A BUSINESS SHOULDN'T BE DONE LIGHTLY, BUT THE REWARDS ARE WORTH THE CHALLENGES.

Trying to launch a business while completing his degree was overwhelming for Bachand at times. "In my last semester, I was taking nine credit hours—the minimum course load—and I had class two days a week," Bachand said. "I was working nonstop and trying to prepare for investor meetings, traveling all the time, trying to graduate and just be a human being."

It was difficult to manage the demands of a young company, and Bachand thought about quitting multiple times, but he said the payoff and the joy he gets out of the work is worth it.

"There's nothing like working on something for weeks and weeks and seeing something that has gone from an idea in your head to solving a real problem," he said. "Finding the answers to problems, getting a better understanding of the challenge and product that we're building is great. It's so much fun."

FINDING A COMMUNITY WITH OTHERS WHO KNOW THE CHALLENGES OF ENTREPRENEURSHIP WAS KEY TO OVERCOMING THE STRESS OF CREATING A STARTUP.

Bachand learned pretty early on in the process of building Instinct Environmental that he couldn't do it with just his cofounder—he needed a larger support system of experienced professionals to lean on. Bachand and Datta were part of a startup accelerator called Techstars based in Boulder, Colorado, to learn the basics of running a business, pitch to investors, raise money and more, and soon found a group of people who understood the unique highs and lows of entrepreneurship.

Eventually, Bachand approached E&I leaders at Mines to gain more support and utilize the resources set up through the E&I ecosystem on campus. Mines offered the fledgling company a space to work and access to experts who offer real-world advice and feedback.

"Everybody wants to help, and that's really cool," Bachand said. "I've met people who founded similar companies and will drop everything to help me debug a problem. We're all just trying to make something we're passionate about, so everyone's really excited and uses their skills to help when they can."

And by working on campus, Instinct Environmental is able to save money, gain access to skilled engineers and network with the right people. "Every cent we make goes toward what we're building and not paying rent on office space and upkeep," Bachand said. "That's given us more runway, and the relationships we're able to build are really helpful."

BACHAND'S ADVICE FOR OTHERS THINKING ABOUT STARTING A BUSINESS: JUST TRY IT.

"If you have an idea and think it could be a business, reach out to people who have done it in the past and ask for their feedback," he said. "There's no right way to do it—your journey is going to be different than mine and from everyone else's. Go to the E&I group and be open and honest about your needs and understand that people want to help you and see you succeed."

CONNECTIONS

► Mines alumni came out to Golden for the first home game of the Oredigger football season against Angelo State University with a tailgate near Marv Kay Stadium in September 2022. ▲

► Several Mines alumni were on hand during this year's M Climb to make sure students' rocks weighed the appropriate 10 pounds before making the trek up Mt. Zion. ▲

Mines alumni showed off their Oredigger pride by participating in several golf tournaments in Golden and Houston this summer to support student scholarships and the Mines experience, including **Dani Nagler '13**.



Theodore Harrison James Bromley



Jaclyn Rose Lawrence



Sara Foster '17 and Alex Booth

1970s

Timothy Haddon '70 was announced as a 2022 inductee into the National Mining Hall of Fame in March 2022.

Hoy Frakes Jr. '75 joined Li-Metal Corp.'s advisory board in May 2022.

Marcus Randolph '77 was named president and CEO of Ecobat in March 2022.

1980s

Mike Maslowski '80 was appointed as vice president and chief operating officer of Sabre Gold Mines Corp. in April 2022.

Wayne Corso '84 was named chief operating officer of Santacruz Silver Mining in August 2022.

Bruce Higson-Smith '84 was appointed to EnviroGold Global Limited's board of directors in May 2022.

Jeff Allison '86 joined Atlas Sand as executive vice president of sales and marketing in June 2022.

David Zanetell '87 was elected to the 2022 National Academy of Construction in August 2022.

Christopher Liner PhD '89 was named an interim associate dean in the Fulbright College of Arts

and Sciences at the University of Arkansas in September 2022.

1990s

Don Cameron '91 was appointed as Alberta Operations site director and vice president of Dow Canada in March 2022.

Samantha Holroyd '91 joined Crestwood Equity Partners' board of directors in July 2022.

Steve Johnston '91, PhD '99 was awarded the 2022 American Solar Energy Society Hoyt Clarke Hottel Award, recognizing outstanding leadership and significant contributions to the

We're proud of Mines alumni. We want to cheer you on and celebrate your accomplishments. Tell us about your recent wedding, a new baby or your new job. Share a personal or professional accomplishment, volunteer activity or your favorite Mines memories. Stay connected to the Oredigger family.

➔ Submit a class note at minesmagazine.com/classnote.



Estelle Kate Pellerin



Neal Matosky '13
and Kelsey Deckert



Haven Zimbra

commercialization of solar energy technologies, in June 2022.

Mauricio Gutierrez MS '99 was appointed to the Texas Economic Development Corporation Board of Directors in July 2022.

2000s

Jennifer Miskimins MS '00, PhD '02 was awarded the 2022 Distinguished Achievement Award for Petroleum Engineering Faculty by the Society of Petroleum Engineers in August 2022.

Lindsey Sayers '02, a senior manager at Southern California Edison, was featured in the company's recent advertising campaign "Creating a Clean Energy Future" and can be seen in TV commercials and on billboards in the Los Angeles area.

Justin Anderson '05, MS '06 joined McGriff Insurance Services as a producer and senior vice

president of the company's mining practice in March 2022.

H. Scott Bromley '09 and **Jaime Bromley '10, MS '18** welcomed a baby boy, Theodore Harrison James Bromley in March 2021, joining big sisters Melody Ruth (8) and Emerson Grace (5).

2010s

Josh Lawrence '10 and **Amanda (Harrington) Lawrence '10** are happy to announce the birth of their second daughter, Jaelyn Rose was born on July 7, 2021, joining her big sister Allison (2).

Joshua Dickerson '12 received the 2022 American Council of Engineering Companies Colorado Young Professional of the Year Award in April 2022.

Ben Makuh '12 graduated from Denver Seminary in May 2022 with a master's degree in biblical and theological studies.



Beck Bennett Bible

Clayton Kyle Bible '13 and **Cassie Jo (Whalen) Bible '15** are proud to announce the birth of their second son, Beck Bennett Bible. Beck arrived on April 4, 2022, joining his big brother Emmett (2).

Samantha (Hawkins) Pellerin '13 and **Taylor Pellerin '13** welcomed a baby girl to their family on December 21, 2021. Estelle Kate Pellerin joins her three older brothers Everett (4), Sawyer (4) and Graham (2).

After altering plans several times due to the COVID-19 pandemic, **Neal Matosky '13** and Kelsey Deckert were married in the mountains above Moab, Utah, on August 1, 2020. Kyle Gough '13 attended the small in-person ceremony, and more than a dozen Mines alumni attended virtually. The couple met in Phoenix, Arizona, in 2014 through a network of Mines alumni friends and coworkers and have been adventuring together ever since.

DAN FOX AWARDED HONORARY ALUMNI STATUS

The Mines Alumni Board awarded Dan Fox, former vice president for student life, honorary alumni status upon his retirement after nearly 20 years of service to Mines. Dan was appointed vice president for student life in 2009. Under his leadership, Mines and the Student Life team established the Center for Academic Services and Advising (CASA), expanded student wellness and safety programs, reached unprecedented levels of success in intercollegiate athletics and fostered the development of co-curricular programming to ensure learning outside the classroom matched the excellence found inside them. He also oversaw the addition of three



new residence halls, major renovations to existing residence halls and the Ben Parker Student Center, construction of the Wellness Center and re-development of the Clear Creek Athletic Complex.



Chris Caskey PhD '14 was named as an inaugural member of the new Colorado Electric Transmission Authority in March 2022.

Ethan Zimbra '14 and **Rebecca Zimbra '15** welcomed a baby girl to their family. Haven arrived on February 26, 2022, joining big brother Everett (2).

Sara Foster '17 married Alex Booth in Fort Davis, Texas, on April 23, 2022. Since Blaster couldn't be present, Pumpkin the burro stepped in to play the part of the beloved Mines

mascot. Pictured with Pumpkin are Haley Salzwedel '16, Chanel Charbonneau '16, Michelle Bonfanti '16, Melody Downs '15, MS '18. The couple met in Midland, Texas.

Caitlin McKennie MS '18 was promoted to talent pipeline economist by the Colorado Workforce Development Council in September 2022. She also recently joined the Payne Institute for Public Policy at Mines as a postdoctoral research associate.

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IN MEMORIAM

Remembering Orediggers who have passed away but will always remain part of the Mines community

Marshall C. Crouch III '67 died April 16, 2022. Born in 1944, Marshall joined the U.S. Army after earning his Mines degree. He began his career as a geologist before starting his own company, White Eagle Exploration. Marshall was involved in the discovery of several natural gas fields in Colorado and Kansas and helped to develop oil and gas fields all over the Rocky Mountain region. He also served on the Mines Foundation Board of Governors.

Royce H. Elliott '66, MS '70 died February 9, 2022. Royce was born in 1944 and spent his whole career with Chevron Oil Company, working his way up to general manager of operations in Kazakhstan before retiring in 2004.

Vernon A. "Bud" Isaacs, Jr. '64 died February 22, 2022. Bud served as a U.S. Army officer in the Vietnam War and spent his career in the oil and gas industry. He also served on the Mines Foundation Board of Governors.

Roberto A. V. Moraes PhD '97 died in October 2021. Roberto worked as geophysicist for several organizations, and after completing his PhD at Mines, he became a professor at the University of Brasilia, where he co-founded the university's applied geophysics laboratory. After retiring, he worked as the chief technology officer of INTERGEO.

Robert L. "Bob" Ball '68 died March 15, 2022. Bob began his career as a staff engineer at Alcan Aluminum. He worked for the company for 33 years.

➔ To submit an obituary for publication in *Mines Magazine*, visit minesmagazine.com/ **obituary**.

➔ Memorial gifts to the Colorado School of Mines Foundation are a meaningful way to honor the legacy of friends and colleagues while communicating your support to survivors. For more information, call **303-273-3275** or visit weare.mines.edu/givingguide.



EMBARK ON AN ADVENTURE WITH THE OUTDOOR RECREATION CENTER

Mines alumni can go on an unforgettable trip to Costa Rica—while helping support opportunities for Mines students

Earlier this year, Mines' Outdoor Recreation Center (ORC) launched the ORC Global Adventures Program to provide opportunities for Mines students to travel to all seven continents during their time on campus. Each semester, students have the opportunity to travel to countries all around the world, participate in outdoor adventures and gain cultural experiences unlike any other.

Now, Mines alumni can get involved and help support these trips for students, all while having an adventure of their own. The ORC is partnering with National Geographic and Global Adventures to offer a special nine-day trip to Costa Rica in May 2023 just for Mines alumni and their family and friends. The trip includes outdoor activities, such as rappelling down a waterfall, paddleboarding on Lake Arenal, a boat tour of Caño Negro Wildlife Refuge, horseback rides, zip-lining, hiking in the Santa Elena Cloud Forest Reserve and much more.

And the best part? Alumni registration funds will help subsidize registration costs for Mines students looking to go on a future ORC-led trip. In this way, Mines alumni can connect with their alma mater and go on an incredible adventure with their fellow Orediggers, all while helping the ORC offer more affordable international adventures for students.

➔ Learn more and register for the Costa Rica adventure at mines.edu/alumni-trip.





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For nearly 100 years, the world's top geophysical engineers have turned to Mines to gain the skills and expertise needed to meet industry demands and build transformative careers. As Mines approaches its 150th anniversary in 2024, we're reflecting on our past as we prepare for what we will accomplish next.

Pictured here is a scientist engaging with geophysical equipment in the Cecil H. Green Geophysical Observatory in Bergen Park near Evergreen, Colorado, in the mid 1960s.

➔ Follow along at mines.edu/mines-at-150.

